The Inheritance of Flower Colour in Antirrhinum majus.

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[Plate 4.]

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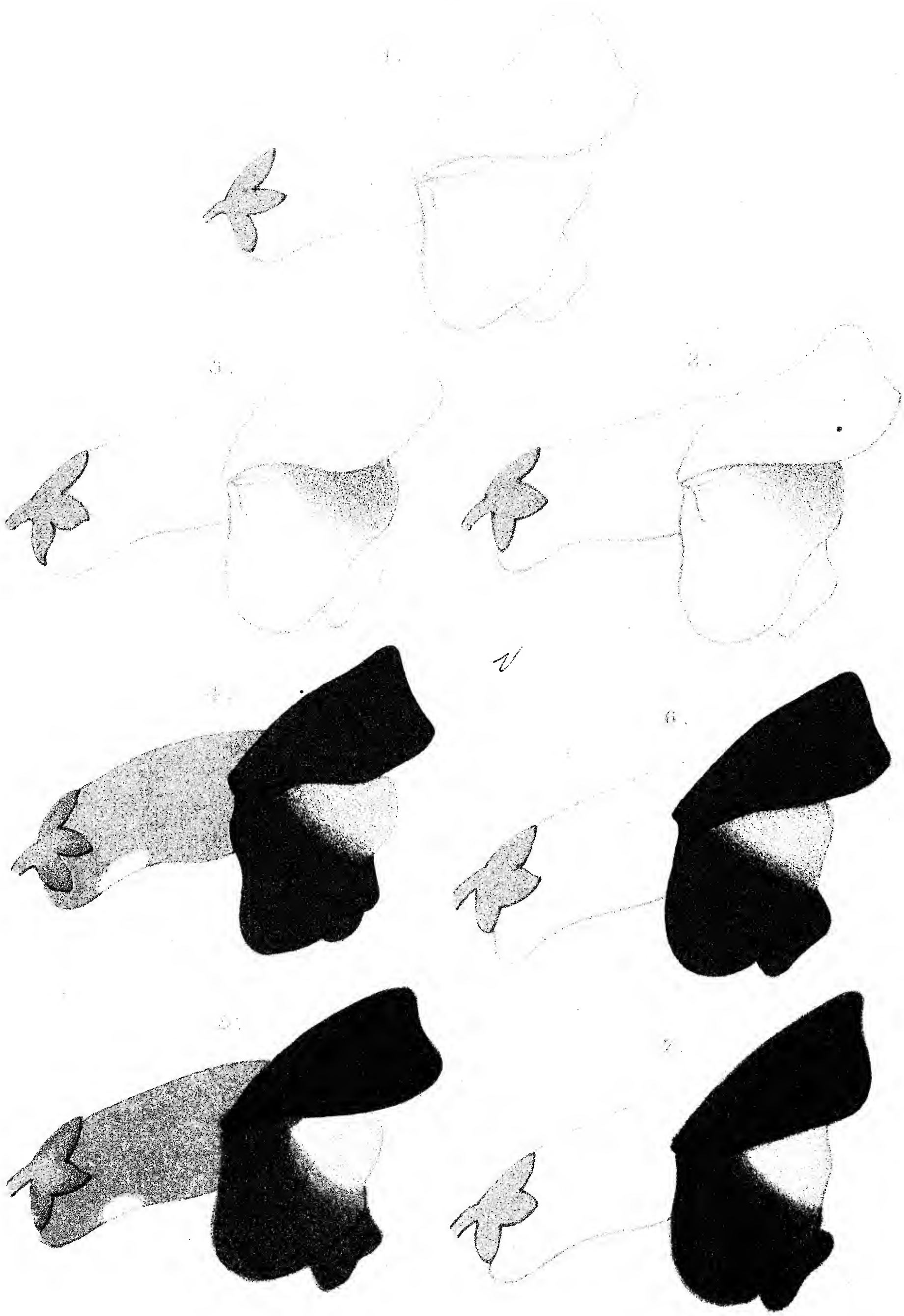
Introduction.

These experiments were begun in June, 1903. The plants used were raised from seed obtained from Messrs. Sutton. The course of inheritance in regard to flower colour was the main object of the enquiry.

Preliminary Statement of Results.

There are as regards colour five easily-distinguishable types of Antirrhinum flowers, namely :—

1. White—Lips and tube pure white (Pl. 4, fig. 1).
2. Yellow—Lips brimstone-yellow; tube ivory. The ivory tube is distinctly recognisable from the pure white tube of the albino (fig. 2).
3. Ivory—Lips and tube ivory. Ivory colour is due to a faint tingeing with yellow, and this type may be regarded as a very pale yellow, but the pigment is, perhaps, distinct from that which gives the yellow colour to Type 2 (fig. 3).
4. Crimson—Lips crimson; tube magenta (fig. 4).
5. Magenta—Lips and tube magenta (fig. 5).



Trap Lith. Leiden.

1. White. 2. Yellow. 3. Ivory. 4. Crimson. 5. Magenta.
6. Crimson delila. 7. Magenta delila.

The colours of all these types are sap-colours, not plastid-colours.

Forms of the crimson and magenta types occur in which the tube is ivory, while the lips are magenta or crimson respectively (figs. 7 and 6). The term "delila" was used by Professor De Vries* for such forms and has been adopted in this paper.

Yellow and magenta colours are produced by the corresponding sap-colours in the cells. Crimson colour in the lips is due to the simultaneous presence of magenta and yellow saps in the cells. That such is the case is easily seen in a microscopical examination of the tissue of the lips of a crimson flower. Groups of cells containing pure yellow or pure magenta saps are found among crimson cells in which the colour is undoubtedly due to a mixture.

With the exception of the albino type, the flowers of all types used have, irrespective of the colour of lips and tube, a constant orange-yellow palate; smaller patches similar in colour generally appear at the base of the tube on either side. This summer Mr. Bateson has shown me white types, some of which had a little orange-yellow colour on the palate, while others had in addition the yellow patches on the tube. Matings will be made with these types, but all whites employed and described in the experimental work have been entirely without colour.

The inheritance of the corolla colours can be represented by the following factors, which have been found to follow the Mendelian inheritance:—

Y.—A factor representing yellow† colour in the lips associated with ivory tube-colour.

I.—A factor representing ivory colour in the lips.

L.— " magenta " "

T.— " " " in the tube.

Small letters, y, i, etc., denote the absence of these factors.

From experimental evidence it appears that:—

1. All zygotes, from which Y is absent, are white, though they may contain any of the factors I, L, and T.
2. The factor T is not manifested unless L is also present in the zygote; that is, no magenta colour appears in the tube unless magenta colour be also present in the lips.
3. All zygotes containing Y are coloured. The actual colour may be modified and determined by the presence of one or more of the remaining factors. A zygote containing Y only or Y and T is yellow.

* 'Mutationstheorie,' Lief. IV, pp. 194—206.

† This, of course, does not refer to palate colour, which may be regarded as a separate character.

4. Ivory is "dominant"* over yellow; a zygote containing Y and I or Y, I, and T, is ivory.
5. Since magenta superposed upon yellow gives crimson, a zygote containing Y, L, and T is crimson, Y and L only, crimson delila.
6. Magenta superposed upon ivory gives, since the latter is very pale, magenta. A zygote containing Y, I, L, and T is magenta, Y, I, and L only, magenta delila.

The five types described are readily distinguishable and quite discontinuous. Throughout the experimental work, all individuals met with have been at once assigned, without any difficulty, to one of the above classes. Magenta colour, however, appears in at least three distinct shades or degrees of concentration, which are probably determined by definite factors, though evidence on this point is not yet complete. Upon a yellow ground, these shades of magenta give the corresponding shades of crimson. In many cases deep magentas have been bred from the lighter magentas, so we must conclude that lighter forms are dominant to darker in the same sense that the pale form, ivory, is dominant to yellow. Similar phenomena have been found to occur in Sweet Peas and Stocks.†

The concentration of sap-colour in the tube and lips is generally approximately the same; the lips are somewhat darker in appearance, but this difference depends probably on texture and not on difference in depth of pigmentation. The tube may also be darker in shade than the lips, and this is the case in one or two types not yet investigated.

The magenta sap-colour sometimes appears in irregular fleckings or stripings, thus giving striped forms. If the striping occurs in the magenta type, the ivory ground-colour shows where the magenta sap fails and the flower may be described as ivory flecked or striped with magenta. When the magenta sap fails in the crimson type, the *yellow* ground-colour appears and the flower would be described as yellow flecked or striped with crimson. No flecking or striping of ivory on yellow has ever been observed.

In several cases, where striped and non-striped forms have been crossed, striping has disappeared in F_1, and has not appeared again either in F_2 or F_3. In another case of striped × non-striped (a paler magenta), the deeper striping persisted in F_1 on the paler magenta ground; a striped F_1 has been given

* "Dominant" is here used to denote that the lighter colours overlie or suppress the darker, as ivory, for example, conceals yellow; and not in its strict sense of expressing the relationship between a pair of allelomorphic characters: ivory and yellow are not, of course, allelomorphic to each other.

† 'Third Report to the Evolution Committee,' W. Bateson, E. R. Saunders, and R. C. Punnett, p. 4.

also in the mating of two striped forms. In the two latter cases the results are not yet complete.

The original wild Antirrhinum appears to be of the magenta type. "Reversion" to this old form, which so often happens when crimson, ivory, or yellow types are crossed with white, is explained by the introduction into the zygote of the factors I, L (and T) by the white parent. The introduction of the factor I alone will bring about "reversion" when L is already present in the zygote.

The experimental evidence is not yet sufficient to determine whether the phenomena in Antirrhinum are fundamentally similar to those observed for Sweet Peas and Stocks. In the two latter cases,* production of colour depends on the simultaneous presence in the zygote of two factors C and R; the absence of both or either of these factors from the zygote renders it white. The colour formed by the meeting of the two factors is red.

To treat the case of Antirrhinum on parallel lines, we might suppose the production of yellow, the base-colour, so to speak, to be due to the presence in the zygote, not of one factor only, but of two factors. Any zygote containing both would be yellow; one only or neither would be white. If such is the case, whites should be found, which, when crossed together, give yellow. Whether this is the case or not cannot be decided yet, since the results of crosses between whites are not known.

All phenomena so far observed in Antirrhinum could be equally well represented on the two-factor theory, provided we assume that the whites, originally mated with coloured types, contained one of the factors which constitute colour; this is quite possible, since so few white *individuals* (only three) were employed in the matings.

The question, then, as to whether colour in Antirrhinum depends on the meeting of two complementary factors or not, must remain open for the present. If two factors be necessary, albinos should be found, which, when mated, give colour (here yellow), as in the cases of Sweet Peas and Stocks; if, on the other hand, only one factor is necessary, then no two albinos when mated will ever produce colour, and the case will be analogous rather to the phenomena observed in animals.

In the Sweet Peas and Stocks, moreover, the colour of the zygote may be further determined by the presence of a third blue factor B, which changes the red colour to purple; but B has no effect unless C and R are also present, and thus may be carried by an albino without producing a sensible effect.

Quite comparable to this third factor in Peas and Stocks are the factors I,

* 'Third Report.

L, and T in Antirrhinum, none of which produce a sensible effect unless yellow is also present. Any of these may be carried by an albino.

The factor I modifies yellow, giving ivory. The factor L, superposed upon ivory, gives magenta; with yellow it blends, giving crimson; finally, the third factor T is not manifested unless L in addition is present.

Details of Various Matings.

WHITE × OTHER TYPES.

White × Yellow Crimson-striped:—

The type yellow crimson-striped is, as explained above, really crimson, in which the magenta sap occurs in irregular stripings and fleckings, so that the lips appear yellow striped with crimson and the tube ivory striped with magenta; a corresponding delila form exists, having an ivory tube.

White has always been found to breed true, but the selfings of the other parent unfortunately failed, so that its constitution can only be deduced from the results of crossing.

F_1 consisted of magentas and magenta delilas (Table I, p. 303).

F_2—The cross-breds appeared to be of four kinds, giving respectively, on selfing:—

	Case 1. Magenta × self.	Case 2. Magenta × self.	Case 3. Magenta delila × self.	Case 4. Magenta delila × self.
Magenta	107	229	—	—
„ delila ...	42	70	59	47
Crimson...........	42	74	—	—
„ delila ...	12	19	18	5
Ivory...............	67	—	19	—
Yellow	24	—	7	—
White	80	97	34	19
Totals	374	489	137	71

If we assume the original parents to be:—

yy II LL tt .... White
YY ii Ll Tt..................... Yellow crimson-striped,

then the cross-breds would be of four kinds:—

Yy Ii Ll Tt..................... Magenta (Case 1)
Yy Ii LL Tt .... „ (Case 2)
Yy Ii Ll tt .... „ delila (Case 3)
Yy Ii LL tt .... „ „ (Case 4),

whole forms and delilas occurring in equal proportions. "Reversion" is here due to the introduction of I by the white parent.

From Case 1, on selfing, we should expect to obtain theoretically as the result of the combination of four pairs of characters:—

		Ratios.	Numbers calculated.	Numbers observed.
Y I L T ...	Magenta	81 or	118·33	107
Y I L	" delila ...	27	39·44	42
Y I T	Ivory	36	52·59	67
Y L T	Crimson...........	27	39·44	42
Y I	Ivory	—	—	—
Y T	Yellow	12	17·53	24
Y L	Crimson delila ...	9	13·15	12
Y	Yellow	—	—	—
—...........	White	64	93·50	80
	Totals	256	373·98	374

From Case 2 we should obtain theoretically:—

		Ratios.	Numbers calculated.	Numbers observed.
Y I T L ...	Magenta	27 or	206·30	229
Y I L	" delila...	9	68·76	70
Y T L......	Crimson...........	9	68·76	74
Y L	" delila...	3	22·92	19
—...........	White	16	122·25	97
	Totals	64	488·99	489

From Case 3:—

		Ratios.	Numbers calculated.	Numbers observed.
Y I L	Magenta delila ...	27 or	57·80	59
Y I	Ivory	9	19·26	19
Y L.........	Crimson delila ...	9	19·26	18
Y	Yellow	3	6·42	7
—...........	White	16	34·25	34
	Totals	64	136·99	137

And from Case 4:—

		Ratios.		Numbers calculated.	Numbers observed.
Y I L	Magenta delila...	9	or	39·94	47
Y L	Crimson „ ...	3		13·31	5
—...........	White	4		17·75	19
	Totals	16		71·00	71

The close agreement between the theoretical and experimental numbers justifies the assumptions made in regard to the constitution of the original parents.

Diagram I represents the composition of F_2 in Case 1 when we consider

YLT YLT	YLT YLt	YLt YLT	YLt YLt	YLT YlT	YLT Ylt	YLt YlT	YLt Ylt
YlT YLT	YlT YLt	Ylt YLT	Ylt YLt	YlT YlT	YlT Ylt	Ylt YlT	Ylt Ylt
YLT yLT	YLT yLt	YLt yLT	YLt yLt	YLT ylT	YLT ylt	YLt ylT	YLt ylt
YlT yLT	YlT yLt	Ylt yLT	Ylt yLt	YlT ylT	YlT ylt	Ylt ylT	Ylt ylt
yLT YLT	yLT YLt	yLt YLT	yLt YLt	yLT YlT	yLT Ylt	yLt YlT	yLt Ylt
ylT YLT	ylT YLt	ylt YLT	ylt YLt	ylT YlT	ylT Ylt	ylt YlT	ylt Ylt
yLT yLT	yLT yLt	yLt yLT	yLt yLt	yLT ylT	yLT ylt	yLt ylT	yLt ylt
ylT yLT	ylT yLt	ylt yLT	ylt yLt	ylT ylT	ylT ylt	ylt ylT	ylt ylt

DIAGRAM I.—Scheme of Distribution of three of the Colour-factors in F_2 from white × yellow crimson-striped.

Cross-hatched squares = crimson-flowered plants.
Single-hatched „ = yellow „ „
Half plain „ = crimson delila flowered plants.
Plain „ = white-flowered plants.

three factors only; the introduction of a fourth factor would give magenta and ivory individuals.

A similar diagram constructed for four factors shows us that, as regards the composition of the F_3 they give on selfing, there are 16 kinds of magentas in F_2. Among 13 magenta plants taken at random in F_2 and selfed, 8 out of the 16 kinds were found. (For Case 1, Table II gives F_3 resulting from all the F_2 individuals selfed.) The remaining 8 would doubtless occur among a larger selection of F_2 individuals.

Of magenta delilas, there are theoretically 8 kinds; 6 plants taken at random gave 2.

Of crimsons, theoretically 8; 5 plants gave 3.

Of crimson delilas, 4; 3 plants gave 2.

Of ivories, 4; 6 plants gave 3.

And of yellows, 2; 3 plants gave both.

A corresponding diagram can easily be constructed for Case 2.

From such a diagram one learns that the F_2 magentas are theoretically of 8 kinds; 11 plants taken at random gave 7 out of the 8. (Table III gives F_3 for Case 2.)

Of magenta delilas, 4; 4 plants gave 4.

Of crimsons, 4; 6 plants gave 4.

Of crimson delilas, 2; only 1 plant was taken.

Two white plants gave whites only.

Similarly, from a diagram constructed for Case 3, we find there are 8 possible magenta delilas; 5 plants gave 5. (Table IV gives F_3 for Case 3.)

Of crimson delilas, 4; 3 plants gave 2.

Of ivories, 4; 1 plant only was taken.

Of yellows, 2; 1 plant only was taken.

Finally, from a diagram for Case 4, we find there are 4 possible magenta delilas; 6 plants gave 2. (Table V gives F_3 for Case 4.) One white plant gave whites only. No other F_2 plants were taken.

It is clear also from Diagram I that there are 8 possible albinos. Various yellows this year have been crossed with a number of F_2 whites as a means of testing for the characters which may be borne by an albino.

White × Crimson Delila:—

Both these types were found to be breeding true.

F_1 consisted of magenta delilas only. (Table I.)

F_2—Two of the cross-breds were selfed, the combined result giving:—

	Number.
Magenta delila	89
Crimson „	34
White	41
Total...........	164

If we assume the original parents to be:—

yy II LL tt .... White
YY ii LL tt .... Crimson delila,

the cross-breds would be of one kind only:—

Yy Ii LL tt .... Magenta delila

"Reversion" is again due to the introduction of I by the white plant.

From selfing the cross-bred we should obtain theoretically:—

		Ratios.		Numbers calculated.	Numbers observed.
Y I L	Magenta delila...	9	or	92·25	89
Y I L	Crimson „ ...	3		30·75	34
—...........	White	4		41·00	41
	Totals	16		164·00	164

There is a close agreement between the theoretical and experimental numbers.

White × *Crimson*:—

The crimson parent was hybrid as regards the characters L and T. F_1, as would be expected, consisted of magentas and magenta delilas. (Table I.) Except as regards striping, this is a case similar to white × yellow crimson-striped, and the same series of types were obtained in F_2 as in the latter case. As yet, sufficient numbers have not been grown to make the details complete.

White × *Yellow*:—

Both parents were breeding true.

F_1 consisted of magenta delilas only. (Table I.)

If we represent the parents by:—

yy II LL tt .... White
YY ii ll tt......................... Yellow,

then the cross-breds would be of one kind only :—

Yy Ii Ll tt .... Magenta delila

F_2 has not been obtained yet.

CRIMSON DELILA × OTHER TYPES.

Crimson Delila × *Yellow Crimson-striped* :—

The crimson delila parent was breeding true. The other parent was the same individual used in the cross white × yellow crimson-striped.

F_1 consisted of crimsons and crimson delilas. (Table I.)

F_2—The cross-breds appeared to be of four kinds, giving respectively, on selfing :—

	Case 1. Crimson × self.	Case 2. Crimson × self.	Case 3. Crimson delila × self.	Case 4. Crimson delila × self.
Crimson...........	56	35	—	—
„ delila ...	24	17	20	23
Yellow	32	—	8	—
Totals	112	52	28	23

If we assume the original parents to be :—

YY ii LL tt .... Crimson delila

YY ii Ll Tt .... Crimson,

then the cross-breds would be represented by :—

YY ii Ll Tt..................... Crimson (Case 1)

YY ii LL Tt .... „ (Case 2)

YY ii Ll tt .... „ delila (Case 3)

YY ii LL tt..................... „ „ (Case 4),

whole forms and delilas occurring in equal proportions.

From Case 1, on selfing, we should obtain theoretically :—

		Ratios.	Numbers calculated.	Numbers observed.
L T Y......	Crimson...........	9	or 63·00	56
L Y.........	„ delila ...	3	21·00	24
T Y.........	Yellow	4	28·00	32
Y...........	„	—	—	—
	Totals	16	112·00	112

From Case 2:—

		Ratios.		Numbers calculated.	Numbers observed.
T Y L......	Crimson...........	3	or	39·00	35
Y L.........	„ delila...	1		13·00	17
	Totals	4		52·00	52

From Case 3:—

		Ratios.		Numbers calculated.	Numbers observed.
L Y.........	Crimson delila ..	3	or	21·00	20
Y	Yellow	1		7·00	8
	Totals	4		28·00	28

And from Case 4 we should get crimson delilas only, which agrees with the experimental result.

In Case 1 there are theoretically 4 kinds of F_2 crimsons; 10 plants taken at random gave 3 kinds. (Table VI gives F_3 for Case 1.)

Of crimson delilas there are two kinds; both were given by 4 plants.

Yellows are of 1 kind only; 8 yellows gave yellows only.

Crimson Delila × *Crimson*:—

The crimson delila parent was breeding true. The crimson parent was shown to be hybrid as regards T, giving, on selfing, 3 crimsons to 1 crimson delila.

F_1 consisted of crimsons and crimson delilas. (Table I.)

F_2—Three crimson delila cross-breds gave crimson delilas only. F_2 has not yet been obtained from the crimsons.

If we assume the parents to be:—

YY ii LL Tt .... Crimson
YY ii LL tt .... „ delila,

the cross-breds would be:—

YY ii LL Tt .... Crimson
YY ii LL tt .... „ delila,

whole forms and delilas in equal proportions, and the latter would give crimson delilas only on selfing, which agrees with the experimental results.

Crimson Delila × Yellow :—

Both parents were breeding true.

F_1 gives the expected result, namely, all crimson delilas. (Table I.)

F_2 has not yet been obtained.

Crimson × other Types.

Crimson × Yellow Crimson-striped :—

The crimson parent was breeding true. The other parent was the plant used in previous crosses.

F_1 consisted of crimsons only. (Table I.)

F_2—Only one cross-bred gave seed and the offspring were crimsons and yellows. The numbers are too small to be of value.

If we assume the original parents to be :—

YY ii LL TT	Crimson
YY ii Ll Tt	Yellow crimson-striped,

the cross-breds would be :—

YY ii Ll TT	Crimson
YY ii Ll Tt.....................	"
YY ii LL TT	"
YY ii Ll Tt.....................	"

All therefore are crimsons, and of these, one, on selfing, namely, YY ii Ll TT, would give crimsons and yellows.

Crimson × Yellow :—

F_1 gave the expected result, namely, all crimsons. (Table I.)

F_2 has not yet been obtained.

Rose × other Types.

The type rose has ivory lips tinged with magenta and a pale magenta tube. The individuals used in crossing were found to breed true. Crosses were made between this and most of the other types, but sufficient numbers have not been obtained in F_2 to give a reliable indication of the results. A type, where "rose," *i.e.*, a tingeing with magenta, is superposed upon a yellow ground (the case where the factor I is missing), appeared in F_2, together with delila forms of both types; this would lead to the supposition that "rose" may be represented by a Mendelian factor.

An interesting point has arisen in connection with the cross rose × a deep crimson delila. The cross-bred is a deep magenta, in which the tube takes the same shade as the lips. This fact suggests, as pointed out elsewhere (p. 301), that there may be a coupling between the shade of tube- and lip-

colour; magenta colour introduced into the tube takes the same concentration as that in the lips.

Experiments of De Vries on Antirrhinum.

In the 'Mutationstheorie,' Lief. IV, pp. 194—206, Professor De Vries gives an account of experiments in crossing certain varieties of *Antirrhinum majus.* It is stated that yellow colour was not taken into consideration and experiments were confined to the white and red varieties. The following is a description of the types mentioned:—

Roth	Tube and lips red, the lips deeper
Fleischfarbig ...	Tube and lips pale red
Delila............	Tube pale or white, lips fairly deep red
Weiss...........	White, often with a distinct very pale red tinge

Professor De Vries regards red as being made up of *fleischfarbig* F and *delila* D, two dominant characters, and white as producing two characters, w and w′, recessive to F and D respectively.

A red Antirrhinum was crossed with white, giving an F_1 like the red parent. From the F_1 cross-breds on selfing, four types were obtained:—the original red, delila, flesh-colour, and the original white, roughly in the proportions 9 : 3 : 3 : 1. This result would be represented:—

Red × white
FD × ww′
↓
FDww′ Red cross-bred

The cross-bred × self would give:—

		Ratios.		Per cent.
FD	Red	9	or	56
F	Flesh-colour	3		19
D	Delila	3		19
ww′	White	1		6
	Total	16		100

The numbers resulting from three experiments were:—

Red	51	58	58
Flesh-colour ...	16	17	11
Delila	31	20	21
White	2	4	10
Totals	100	99	100

The reds in F_2 are of four kinds and would on self-fertilisation give in F_3 the following results :—

1 FD $\longrightarrow$ FD red
2 FDw′ $\longrightarrow$ FD (red) + Fw′ (flesh-colour)
2 FDw $\longrightarrow$ FD (red) + Dw (delila)
4 FDww′ $\longrightarrow$ the whole series again

The delilas are of two kinds :—

1 Dw $\longrightarrow$ Dw (delila)
2 Dww′ $\longrightarrow$ Dw (delila) + ww′ (white)

The flesh-colours also :—

1 Fw′ $\longrightarrow$ Fw′ (flesh-colour)
2 Fww′ $\longrightarrow$ Fw (flesh-colour) + ww′ (white)

Professor De Vries showed that a delila and a flesh-colour in F_2 gave, on selfing, an F_3 consisting of delilas only and flesh-colours only respectively. Other F_2 delilas gave delilas and whites and other F_2 flesh-colours gave flesh-colours and whites. Further, among the F_2 reds, some gave reds and flesh-colours in the proportion 3 : 1, while others gave reds and delilas in the same proportion.

Professor De Vries has kindly informed me that his types correspond to the following types mentioned in this paper, namely :—

Roth	to	Magenta	
Delila	„	„	delila
Fleischfarbig	„	Rose	
Weiss	„	Ivory	
„ (tinged)	„	Rose delila	

Rose × a delila form has been found to give a deep magenta whole form (p. 299) and the result is consistent with the supposition that there is an inter-dependency between the shade of colour in lips and tube ; the magenta tube-colour, introduced by rose, takes, in the cross-bred, the same shade as the lip-colour. This result corroborates Professor De Vries' suggestion that *roth* consists of *fleischfarbig* and *delila.**

Translated into the types used in this paper, the simplest expression for

* [In 'Camb. Phil. Soc. Proc.,' vol. 12, 1902, p. 50, I suggested an interpretation of De Vries' results with Antirrhinum, which then seemed to me preferable to that put forward by him. Further evidence as to this and other cases of the resolution of compound characters has shown that my suggestion was incorrect (see also 'Rep. Evol. Com.,' III, p. 12).—W. Bateson.]

Professor De Vries' parent plants would be (Rl = rose lips, Rt = rose tube):—

YY II Rl Rl LL Rt Rt...... Magenta (Rl Rt L = magenta)
YY II rl rl ll rt rt .... Ivory

and the cross-breds:—

YY II Rl rl Ll Rt rt......... Magenta

would give, on selfing:—

		Ratios.	Numbers calculated.	Numbers observed.
			per cent.	per cent.
Rl L Rt ...	Magenta	36 or	56	56
Rl L	„ delila......	12	19	24
Rl Rt	Rose	9	14	15
L Rt	Magenta	—	—	—
Rl	Rose delila	3 } 7	11	5
L	Magenta delila......	—		
Rt	Ivory	4		
—...........	„	—	—	—

The ivories and rose delilas are classed together as De Vries' whites and tinged whites. The numbers observed are the mean of those given for the three experiments; moreover, the various kinds of *roth* and *fleischfarbig* would be found among the above F_2 forms.

In conclusion, I wish most sincerely to thank Miss Saunders and Mr. Bateson for the advice and help they have kindly given me, both as regards many practical details and in the writing of this paper.

I am also indebted to Mr. Lynch, of the Botanic Gardens, Cambridge, for allowing me space under cover every year for the germination of my seedlings.

Table I.—F_1 from Matings between various Types.

Matings.	Colours in F_1.				
	Magenta.	Magenta delila.	Crimson.	Crimson delila.	Rose.
White × yellow crimson-striped ...	24	19*			
„ × crimson delila	...	33			
„ × crimson	4	4			
„ × yellow	...	21			
Crimson delila × yellow crimson-striped	...	...	36	35	
„ × crimson	...	...	8	10	
„ × yellow	...	...	...	22	
Crimson × yellow crimson-striped...	...	...	36		
„ × yellow	...	...	23		
Rose × white	184				
„ × crimson	25				
„ × crimson delila.................	30				
„ × yellow crimson-striped	19				
„ × yellow	...	...	...	...	20
„ × ivory	...	...	...	...	20 (paler)

* The small total here may be due to the fact that a large number of F_1 individuals were destroyed by frost.

Table II.—F_3 from Case 1 in the Mating White × Yellow Crimson-striped.

Number of F_2 individuals.	Colour of F_2 individuals.	Colours in F_3.						
		Magenta.	Magenta delila.	Crimson.	Crimson delila.	Ivory.	Yellow.	White.
3	Magenta	+	+	+	+	+	+	+
1	„	+	+	+	+	+	+	
3	„	+	...	+	...	+	+	+
1	„	+	+	...	...	+		
2	„	+	...	+	...	+	+	
1	„	+	+	...	...	...	...	+
1	„	+	...	...	...	+		
1	„	+	+	+	+	...	...	+
5	Magenta delila	...	+	...	+	+	+	+
1	„ „	...	+	...	...	+	...	+
2	Crimson.........	...	...	+	+	...	+	+
1	„	...	...	+	...	...	+	+
2	„	...	...	+	...	...	+	
2	Crimson delila	...	...	...	+	...	+	
1	„ „	...	...	...	+	...	...	+
2	Ivory	...	...	...	...	+	+	
2	„	...	...	...	...	+	...	+
2	„	...	...	...	...	+		
2	Yellow	...	...	...	...	...	+	+
1	„	...	...	...	...	...	+	

Table III.—F_3 from Case 2 in the Mating White × Yellow Crimson-striped.

Number of F_2 individuals.	Colour of F_2 individuals.	Colours in F_3.				
		Magenta.	Magenta delila.	Crimson.	Crimson delila.	White.
2	Magenta	+	+	+	+	+
2	"	+	+	+	+	
3	"	+	+	...	...	+
1	"	+	+			
1	"	+	...	+	...	+
1	"	+	...	+		
1	"	+				
1	Magenta delila	...	+	...	+	+
1	" "	...	+	...	+	
1	" "	...	+	...	...	+
1	" "	...	+			
1	Crimson............	...	...	+	+	+
1	"	...	...	+	...	+
2	"	...	...	+	+	
2	"	...	...	+		
1	Crimson delila	...	...	...	+	+
2	White	...	...	...	...	+

Table IV.—F_3 from Case 3 in the Mating White × Yellow Crimson-striped.

Number of F_2 individuals.	Colour of F_2 individuals.	Colours in F_3.				
		Magenta delila.	Crimson delila.	Ivory.	Yellow.	White.
1	Magenta delila	+	+	+	+	+
1	"	+	+	+	+	
1	"	+	+	...	...	+
1	"	+	...	...	...	+
1	"	+	...	+		
2	Crimson delila	...	+	...	+	
1	"	...	+	...	...	+
1	Ivory	...	...	+	+	+
1	Yellow	...	...	...	+	+

Table V.—F_3 from Case 4 in the Mating White × Yellow Crimson-striped.

Number of F_2 individuals.	Colour of F_2 individuals.	Colours in F_3.		
		Magenta delila.	Crimson delila.	White.
2	Magenta delila	+	+	
4	"	+	...	+
1	White...........	...	...	+

Table VI.—F_3 from Case 1 in the Mating Crimson Delila × Yellow Crimson-striped.

Number of F_2 individuals.	Colour of F_2 individuals.	Colours in F_3.		
		Crimson.	Crimson delila.	Yellow.
5	Crimson	+	+	+
3	"	+	...	+
2	"	+		
2	" delila	...	+	+
2	" "	...	+	
8	Yellow	...	...	+

Longitudinal Symmetry in Phanerogamia.

By Percy Groom, M.A., D.Sc., F.L.S.

(Communicated by Dr. D. H. Scott, F.R.S. Received January 24,—Read February 21, 1907.)

(Abstract.)

The first object of this communication is to put forward a simple *graphic method* of recording measurements concerning the longitudinal symmetry of plants, and to test its efficiency as a means of solving morphological problems. The method is as follows:—Measurements of the successive internodes of a stem are made, and are recorded on squared paper as successive ordinates; the resultant curve is termed the *internode curve.* The longitudinal distances apart of other members are dealt with in the same manner, and ranged into other curves.

The second object of the paper is to describe the general and particular results obtained by use of the method.

In a *typical herb,* the internode curve of the main axis is a regular and characteristic ascending-descending one (see Curve 1 in fig. 1), while those of

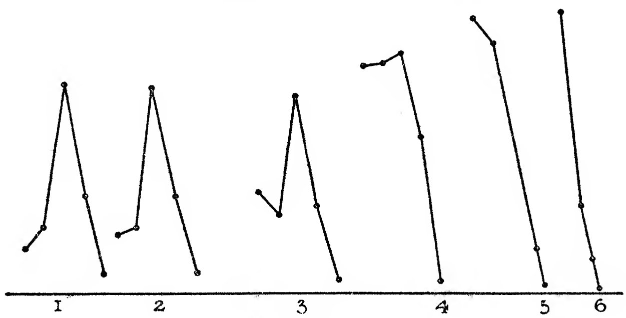


Fig. 1.

1 White. 2 Yellow. 3 Ivory 4 Crimson. 5. Magenta.
6 Crimson delila. 7. Magenta delila.